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August 20, 2004

Dorothy Shimer
Research Division
Air Resources Board
P.O. Box 2815
Sacramento, California 95812

RE: Draft Report to the California Legislature on Indoor Air Pollution in California

Dear Ms. Shimer:

The Southern California Gas Company (SoCalGas) and San Diego Gas and Electric (SDG&E) appreciate the opportunity to comment on the draft Report to the California Legislature – Indoor Air Pollution in California.

After reviewing the report, we are concerned that many of the assertions related to natural gas appliances and their impact on indoor air pollution are overstated and fail to recognize the complex issues regarding mitigating indoor pollutants. SoCalGas and SDG&E have endeavored to understand this important issue and we want to assist the state in its effort.

We disagree with assertions in the report that gas appliances need additional regulation by the state or that they do not currently meet extensive regulations for their installation and use. We also fail to understand how it was determined that natural gas appliances should be ranked in the order of priority that they currently are in the draft report.

SoCalGas is the nation's largest natural gas distribution utility, serving 19 million people through 5.4 million gas meters in more than 530 communities, and SDG&E serves over 3 million consumers through 1.3 million electric meters and 800,000 natural gas meters in Southern California. We have conducted several large scale studies of indoor air quality for over 20 years to better understand the impact that gas appliances have on indoor air quality, personal exposures, and appliance safety. Some of our work is cited in the draft report. We have also taken a proactive posture to ensure that up-to-date natural gas and propane appliance safety standards and installation codes are available for adoption by California regulatory agencies.

We have included our specific comments in seven attachments to this letter. Listed below are the recommendations discussed in each attachment:

A. Comments on Existing Regulations, Guidelines, and Practices

1. Clarify that gas-fired vent-free space heaters and gas-fired cooking appliances are separate categories of appliances, as outlined in our other comments.
2. Delete the comments regarding the removal of gas-fired cooking appliances from homes and revise the speculative statements about normally operated gas-fired cooking appliances creating excessive levels of indoor air pollution.
3. Delete or clarify the discussion on combustion appliance safety (CAS) testing to reflect the actual status of CPUC deliberations on the issue.
4. Clarify that gas-industry safety standards are “voluntary consensus” standards, and not industry promulgated test standards as stated in the report.

5. Clarify the discussion on ASHRAE 62.2 as outlined in our comments to report the factual status of the standard.

B. Comments on Methods to Prevent and Reduce Indoor Air Pollution

1. Delete the discussion about improving appliance efficiency. This is covered by federal law and is not an appropriate topic of discussion for this report.
2. Remove or modify the reference to the use of exhaust hoods being "especially critical" for gas-fired ranges and ovens. The use of exhaust hoods to remove emissions is just as important for electric ranges as gas-fired ranges because the emissions from the food being cooked is the primary concern.

C. Comments on Options to Mitigate Indoor Air Pollution

1. Remove recommendation 7 regarding combustion appliances.

D. Comments on Asthma and Natural Gas Appliances

1. Include electric cooking appliances when discussing NO2 emissions and impacts.
2. Discuss combustion appliances by fuel type and appliance type whenever possible.
3. Remove gas cooking appliances from unvented gas combustion category.
4. Include recent articles suggesting that NO2 levels and gas stoves are not associated with asthma to balance the other references that are cited.

E. Comments on Unintentional CO Deaths

1. Revise the death rate assumptions and the resulting costs presented on pages 80, 81 and 133.
2. Separate natural gas combustion from other combustion sources in the tables to reflect the lower CO death rates from natural gas appliances.
3. Delete assertions that CO alarms have reduced unintentional non-vehicular CO death rates.

F. Comments on Cooking Emissions

1. Revise statements made about cooking emissions to make it clear that all cooking appliances (gas, electric, microwave ovens, toasters, etc) are included.
2. Include electric cooking appliances in discussions of CO, NO2, formaldehyde and PAH emissions and impacts.
3. Include all cooking appliance types when discussing the need to control emissions, ventilate the home, reduce health effects or reduce impacts.

G. Comments on Ranking Source Categories

1. List pollutants (not source categories) ranked by high, medium and lower priorities.
2. Fully describe the methodology used in the ranking process or algorithm.
3. List the specific empirical data or other scientific information used.

We look forward to working with you on this most important issue. Should you have any questions regarding these comments, please contact Lance DeLaura, National Codes/Standards and Emerging Technologies Manager for Sempra Energy Utilities at (213) 244-3678, or me at (916) 492-4244.

Sincerely,

Bernie Orozco

Attachment

Southern California Gas Company
And
San Diego Gas and Electric

Comments On
Draft Report to the California Legislature on Indoor Air Pollution in California

Attachments A-G

Attachment A

Comments on Existing Regulations, Guidelines, and Practices

Remarks

Natural gas unvented decorative and heating appliances are not allowed to be installed or sold in the State of California. These appliances have been the subject of regulation since 1951 when the California State Housing Act was amended to require all appliances except gas ranges, hot plates and refrigerators to be vented.

The allegation that "unvented gas stoves" can be a major source of pollution is not supported either by this report or existing standards, codes, or regulations. It is not clear how this report means to address malfunctioning appliances or catastrophic failures through additional regulation. Extensive regulations already exists. If ARB staff believes that existing regulations cannot assure adequate IAQ from misused and malfunctioning appliances, it should be explained how more regulations on natural gas appliances will improve the situation, and at what cost.

Since the discussion under "Unvented Appliances" in this section seems to be focused on the potential use of kerosene heaters, we recommend that the title be changed to reflect that fact. In addition, we do not understand the value of including the information related to SB 798 since no actions were taken and the use of unvented decorative space heaters are still banned. It does not add value to the report in our opinion and should be deleted.

We believe that the statements regarding the "potential" for "unvented cooking appliances" to trigger "serious health effects such as CO poisoning or asthma attacks" throughout the report to be misleading and not in the proper context of the issue. Gas-fired cooking appliances are not required to be vented although many homes have exhaust hoods vented to the outside. It is not appropriate to refer to gas ranges in the same manner as unvented space heating appliances.

Cooking appliances are rarely used at full input rates, and then only for short durations because food would not be cooked properly. In those instances where someone uses a cooking appliance for space heating, it is unclear how IAQ regulations could prevent that misuse unless the appliance and the operator were continuously monitored. The fact is that millions of people use gas-fired cooking appliances daily without serious health effects, and that fact should also be reflected in the report.

The need to operate exhaust hoods during cooking activities is a separate issue from CO poisoning and asthma attacks since it applies equally to cooking of food on both gas and electric appliances. The cost of retrofitting every home in California with a vent hood that properly removed cooking by-products is enormous, and could be the subject of its own regulatory action. The entire kitchen area would need to be vented, including microwave ovens and toasters.

The assertion in the report to remove gas-fired cooking appliances from homes appears to be misguided, and not based on the evidence that millions of people use gas-fired cooking appliances daily without any adverse health effects. The California Energy Commission Residential Appliance Saturation Survey (RASS) published June, 2004 shows that 55% of ovens, and 63% of ranges are gas-fired in California. Changing those appliances to electric would be a monumental task, with minimal IAQ benefits since ARB's own studies show that it is what you are cooking, not what you are cooking with, that is the primary concern.

The report's depiction of the Combustion Appliance Safety (CAS) test as a means of improving IAQ should also be deleted. There is no program to evaluate the skill level of contractors performing CAS tests, so it is unknown exactly what impact this protocol has provided other than raising the cost of weatherization. As noted in the report, the CPUC evaluated a request to mandate CAS testing in the statewide LIEE program. After two years of study, a significantly modified natural gas testing protocol was adopted by the Commission that does not require the extensive pre and post testing for natural gas appliances as advocated by some weatherization groups. No studies exist that we are aware of which show any IAQ benefit from CAS testing, in any of its many forms, in the state of California. While state weatherization contractors do perform some type of CAS test, it should be noted that the contractors are guaranteed funding to provide this service. It is not clear that this type of program would exist in a competitive market, due to its extraordinary costs and lack of defined benefits.

In section 4.3.2.3, the report discusses the use of "industry-promulgated test standards" to test for CO emissions in the last paragraph on page 103. This statement is incorrect and needs to be revised. The natural gas industry has developed voluntary consensus standards for 80 years, and has a strong record in supporting natural gas safety. The Accredited Standards Committee Z21/83 develops standards for fuel gas appliances and accessories that are approved by the American National Standards Institute (ANSI) as consensus standards. The committee consists of utility, manufacturer, consumer, government (including the CPSC), code enforcement, and individual members who voluntarily provide their time and expertise to continuously develop and update the Committee's standards for gas-fired appliances. These standards are "state-of- art", and accepted by regulatory agencies throughout the United States, including the State of California. Section 4.4.3 discusses the important role that "consensus" standards play in improving IAQ. This is exactly the type of standards that the gas industry develops.

In addition, the comment that the standards for gas stoves would allow excessive levels of indoor air pollution to build up is speculative and should be removed from the report. A number of factors prevent this from happening in the real world. For one, the heat buildup alone from the operating stove requires people to open windows or doors or shut down the appliance, in order to keep the cooking area bearable. The only time a gas range can run continuously when people are in the room is if they have excessive ventilation. Normal people do not leave stoves on at full input during the cooking process to avoid burning their food. If these appliances are left on at full input, it is due to misuse.

Section 4.4.1 of the report discusses State Regulation by the California Energy Commission (CEC) in some detail. The report correctly states that the CEC does not "directly regulate the operation and maintenance of buildings and appliances" during its energy conservation standards development activity. However, the report fails to mention that the CEC must, by law, do a California Environmental Quality Act (CEQA) analysis of any regulations it promulgates that may impact IAQ. The CEC recently issued another Negative Declaration for CEQA regarding its 2005 standards, as it has done in the past after extensive staff analysis. We suggest that the report discuss this important requirement as an example of how the State of California addresses IAQ concerns today.

Section 4.4.3.3 discusses ASHRAE Standard 62.2, and misstates the standard as adopted. This section should be revised and the incorrect statements removed. ASHRAE 62.2 only requires whole house mechanical ventilation in certain DOE climate zones, has deleted the requirement for combustion appliance testing (backdraft testing), and never contained a requirement for CO alarms. In addition, the version of the standard that contained the combustion appliance testing is under appeal at ANSI for being in conflict with existing ANSI standards and it is inappropriate to imply this is actually a requirement of the standard until the appeal is settled. That requirement was subsequently removed by the 62.2 Committee as its first addendum after further deliberation by the Committee.

Recommendations

1. Clarify that gas-fired vent-free space heaters and gas-fired cooking appliances are separate categories of appliances, as outlined in our other comments. Delete the comments regarding the removal of gas-fired cooking appliances from homes and revise the speculative statements about normally operated gas-fired cooking appliances creating excessive levels of indoor air pollution.
2. Delete or clarify the discussion on combustion appliance safety (CAS) testing to reflect the actual status of CPUC deliberations on the issue.
3. Clarify that gas-industry safety standards are "voluntary consensus" standards, and not industry promulgated test standards as stated in the report.
4. Clarify the discussion on ASHRAE 62.2 as outlined in our comments to report the factual status of the standard.

Attachment B

Comments on Methods to Prevent and Reduce Indoor Air Pollution

Remarks

Section 5.1, on page 118 of the report, makes the statement that "Appliance standards can also be improved to increase combustion efficiency as well as energy efficiency, thereby lowering indoor and outdoor air emissions." This statement seems to address only gas-fired appliances, ignoring electric appliances that also use energy and create air pollution. Most appliance energy efficiency regulations are promulgated by the Department of Energy (DOE), following Federal law. States are pre-empted from setting efficiency standards, so this discussion is moot, as well as speculative, and should be removed from the report.

Section 5.2, page 119, states that "The use of exhaust hoods ducted to the outdoors is especially critical when using gas stoves or ovens, in order to remove the emissions from the appliance and those generated during cooking, which can be substantial." While it is not clear from the statement which emissions are substantial, it is incorrect to imply that the use of exhaust hoods is "critical" for gas appliances.

No evidence is contained in the report that gas cooking appliances are dangerous, and in fact, a recent memorandum by the CPSC bears out the fact that gas-fired cooking appliances are not a major health concern.

On January 10, 2001, the CPSC submitted a health assessment for CO from gas-fired ovens based on results of testing and analysis done by their contractor, the National Institute of Standards and technology (NIST) to the Z21/83 Household Cooking Appliance subcommittee. CPSC had received requests to mandate a lower CO emission limit for gas ranges based on health concerns, and a study done in Oregon.

In an August 24, 2000 memorandum, CPSC concluded that "When used as intended, unvented gas ranges do not generally produce CO levels of consequence to healthy consumers, even if oven vents are up to 50% occluded." The memorandum went on to state that even when used as a space heater for short durations, or when operated as intended by the manufacturer in small spaces, CO levels are not likely to be of health concern unless the oven vents are 100% occluded.

The draft report unfairly implies that gas-fired ranges are dangerous to consumers and should be removed or required to be vented to the outdoors.

Recommendations

1. Delete the discussion about improving appliance efficiency. This is covered by federal law and is not an appropriate topic of discussion for this report.

2. Remove or modify the reference to the use of exhaust hoods being “especially critical” for gas-fired ranges and ovens. The use of exhaust hoods to remove emissions is just as important for electric ranges as gas-fired ranges because the emissions from the food being cooked is the primary concern.

References

Inster, Sandra E; Carbon monoxide (CO) emissions from residential gas ranges: projected customer exposure and related health concerns, Memorandum to Ron Jordan, US Consumer Products Safety Commission, Washington DC, August 24, 2000

Attachment C

Comments on Options to Mitigate Indoor Air Pollution

Remarks and Recommendations

We disagree with the need to have the state set emission standards for combustion appliances or require emission testing of combustion appliances by manufacturers.

There is no evidence to suggest that the State of California could develop better standards for gas-fired appliances than the existing voluntary consensus standards committee. An effort like this would only result in higher costs for consumers, limit appliance choices, and provide no discernable improvement in IAQ based on the information provided in the report.

Implementing recommendation 7, which appears to ban all combustion appliances from inside residences, whether they are operating normally or not, would be extremely costly and disruptive to the state and its consumers and businesses. It should be removed as an option as entirely unnecessary and unworkable.

Attachment D

Comments on Asthma and Natural Gas Appliances

Remarks

Asthma is a serious disease affecting a large portion of the population and the number of cases has dramatically increased during the last 20 years. It is clear that high levels of air pollution (indoors or outside) can impair lung function and exacerbate asthma. High levels of ozone may even have caused some cases of asthma. However, it is unclear why asthma rates have increased so dramatically. This increase does not seem to correlate with air pollution trends. Outdoor (and presumably indoor) levels of NO_2, PM and ozone have been steadily decreasing for many years both in California and nationwide. However, the asthma rates have been increasing. This implies that reducing indoor levels of those pollutants may not reduce the asthma rates. We believe that this issue was not adequately discussed in the draft report.

Two pollutants emitted from gas appliances have been identified in the draft report with worsening of asthma: NO_2 and particulate matter. The health implications of high levels of particulate matter and NO_2 are severe and have been confirmed through numerous studies. The role of natural gas appliances and other combustion devices in elevating indoor level of those pollutants is complex and it would be more precise to discuss these devices by fuel type and appliance type.

Particulate mass emissions from natural gas combustion are very low and it is highly unlikely that natural gas appliances in our service territory could significantly contribute to particulate matter mass concentrations found in homes. However, cooking activities (both gas and electric) can produce sufficient amounts particulate matter that will have a measurable impact on indoor levels. However, other combustion fuels (wood, oil) can routinely produce significant amounts of particulate matter. Combining all combustion fuels into one category is misleading when discussing particulate matter emissions.

NO_2 emissions from all combustion sources can certainly contribute to indoor concentration. NO_2 data have been collected by gas utilities in California for a large number of homes over the past 20 years in order to better understand the impact of natural gas appliances.[1-21] In 1984 we sampled nearly 600 homes; in 1986 we screened over 1000 homes for NO_2 and tested over 250 for several weeks; in 1988 we conducted an NO_2 personal exposure assessment for over 700 people; and in 1991 we tested over 200 homes statewide. The above studies measured 7-day or 2-day average concentrations and can be used to assess the impact on NO_2 and other pollutants. Data regarding shorter averaging times that would be sufficient to make general statements about the entire population is not available.

The potential impact of natural gas appliances on indoor NO_2 is vastly different for each type of appliance. The draft report tends to discuss vented and unvented gas appliances which is a good first categorization. However, it is not very useful to place unvented gas

heaters and gas cooking appliances in the same category when discussing indoor air quality.

Unvented gas heaters are not allowed to be sold in California. SoCalGas and SDG&E will turn off any such device and warn the customer not to use it. We believe that unvented heaters are rarely used in our service territory.

Gas cooking appliances are rarely directly vented to the outside and therefore we can understand categorizing them separately from a vented appliance. However, most gas cook tops have fume collection hoods. Many of those hoods exhaust the fumes and odors outdoors. However, the collection efficiency of the exhaust fans is low and they are not used for all cooking activities. Rather than categorizing gas cooking appliances as unvented appliances perhaps it would be useful to discuss top burners and oven/broilers. Many homes in our service territory actually have gas fired top burners and electric oven/broilers.

We do not wish to dismiss the seriousness of asthma or to imply that some natural gas appliances do not potentially contribute to worsening asthma. However, given the complexity involved with determining the actual contribution of natural gas appliances to asthma, we would suggest that the report give a more balanced discussion on the association of natural gas cooking and NO_2 with asthma.

We suggest that the report consider two recent studies:

- The ARB-funded Children's Health Study (Peters, 2004) has recently been published and represents an excellent large source of information that will be used for many years. One issue that we suggest to be considered is the data presented in Table 4.2-9 of the Peter's report. In that study, elevated levels of ambient NO_2 was not significantly associated with children's asthma (current or ever) but was perhaps important for wheezing in boys but not girls.

- A recent NIH funded study (Eisner, 2003) of adults with asthma concluded "...there was no apparent impact of gas stove exposure on the respiratory health of adults with asthma…" and "It appears unlikely that gas stoves has contributed significantly to the recent rise in worldwide asthma morbidity and mortality".

Recommendations

1. Include electric cooking appliances when discussing NO_2 emissions and impacts.
2. Discuss combustion appliances by fuel type and appliance type whenever possible.
3. Remove gas cooking appliances from unvented gas combustion category.

4. Include recent articles suggesting that NO2 levels and gas stoves are not associated with asthma to balance the other references that are cited.

References for Asthma Comments

Peters, J.M., et al; Epidemiologic Investigation To Identify Chronic Effects of Ambient Air Pollutants in Southern California; Prepared for the California Air Resources Board and the California Environmental Protection Agency, Contract No. 94-331, May 2004

Eisner, M.D., Blanc, P.D.; Gas stove use and respiratory health among adults with asthma in HHANES III; Occup Environ Med, 2003; 60:759-764.

References for California Utility Sponsored IAQ and Personal Exposure Studies

1 Wilson, A.L., Colome, S.D., Baker, P.E. and Becker, E.W. Residential Indoor Air Quality Characterization Study of Nitrogen Dioxide, Phase I, Final Report. Prepared for Southern California Gas Company, Los Angeles, 1986.

2 Baker, P.E., Cunningham, S.J., Becker, E.W., Colome, S.D. and Wilson, A.L. "Evaluation of Housing and Appliance Characteristics Associated with Elevated Indoor Levels of Nitrogen Dioxide". In: Indoor Air '87; Proceedings of the Fourth International Conference on Indoor Air Quality and Climate, B. Seifert, H. Esdorn, M. Fischer, H. Ruden, J. Wegner, eds. Institute for Water, Soil and Air Hygiene, Berlin, FRG, 1:390-394, 1987.

3 Baker, P.E., Cunningham, S.J., Becker, E.W., Colome, S.D. and Wilson, A.L. "An Overview of the Residential Indoor Air Quality Characterization Study of Nitrogen Dioxide". In: Indoor Air '87; Proceedings of the Fourth International Conference on Indoor Air Quality and Climate, B. Seifert, H. Esdorn, M. Fischer, H. Ruden, J. Wegner, eds. Institute for Water, Soil and Air Hygiene, Berlin, FRG, 1:395-399, 1987.

4 Beals, S.A., Holiman, J.C., Kubo, R., Rubio, S.A., Stanford, R., Colome, S.D. and Wilson, A.L. Residential Indoor Air Quality Characterization Study of Nitrogen Dioxide, Phase II, Final Report: The Wall and Floor Furnace Inspection Study. Prepared for Southern California Gas Company, Los Angeles, 1987.

5 Colome, S.D., Wilson, A.L., Becker, E.W., Cunningham, S.J. and Baker, P.E. "Analysis of Factors Associated with Indoor Residential Nitrogen Dioxide: Multivariate Regression Results". In: Indoor Air '87; Proceedings of the Fourth International Conference on Indoor Air Quality and Climate, B. Seifert, H. Esdorn, M. Fischer, H. Ruden, J. Wegner, eds. Institute for Water, Soil and Air Hygiene, Berlin, FRG, 1:405-409, 1987.

6 Colome, S.D., Wilson, A.L., Becker, E.W., Cunningham, S.J. and Baker, P.E. "Temporal Evaluation of Nitrogen Dioxide in Thirty Seven Residences". In: Indoor Air '87; Proceedings of the Fourth International Conference on Indoor Air Quality and Climate, B. Seifert, H. Esdorn, M. Fischer, H. Ruden, J. Wegner, eds. Institute for Water, Soil and Air Hygiene, Berlin, FRG, 1:410-414, 1987.

7 Colome, S.D., Baker, P.E., Beals, S.A., Rubio, S.A., Cunningham, S.J., Billick, I.H. and Wilson, A.L. "A Crossover Design Study to Investigate the Effectiveness of Appliance Inspection and Servicing for Lowering Indoor Nitrogen Dioxide Concentrations". Presented at the annual meeting of the Air Pollution Control Association, Dallas, 1988.

8 Colome, S.D. and Wilson, A.L. Personal Exposure to Nitrogen Dioxide in Microenvironments. Prepared for Southern California Gas Company, Los Angeles, July, 1989.

9 Cunningham, S.J., Baker, P.E., Beals, S.A., Becker, E.W., Colome, S.D., Wilson, A.L., Billick, I.H., Spengler, J.D. and Ryan, P.B. "Personal Exposure to Nitrogen Dioxide in Los Angeles". Presented at the International Gas Research Conference, Tokyo, Japan, November 6-9, 1989.

10 Schwab, M., Spengler, J.D., Ryan, P.B., Colome, S.D., Wilson, A.L., Becker, E. and Billick, I.H. "Describing Activity Patterns for Use in Exposure Assessment: Data from the Los Angeles Personal Monitoring Study". Presented at the 82nd Annual Meeting of the Air & Waste Management Association, Anaheim, California, 1989.

11 Wilson, A.L., Colome, S.D., and Tian, Y. California Residential Indoor Air Quality Study, Volume I, Methodology and Descriptive Statistics. Prepared for Gas Research Institute, Pacific Gas and Electric Company, San Diego Gas and Electric Company and Southern California Gas Company, May, 1993.

12 Becker, E.W., Behar, J.V., Wilson, A.L., Tian, Y. and Colome, S.D. "Radon Concentrations Inside California Homes". Presented at the Air and Waste Management Association 87th Annual Meeting and Exhibition, June 19-24, 1994, Cincinnati, Ohio.

13 Behrens, D.W., Becker, E.W., Billick, I.H., Garrison, C.A., Wilson, A.L., Colome, S.D. and Tian, Y. "California Residential Indoor Air Quality Study: An Overview". Presented at the Air and Waste Management Association 87th Annual Meeting and Exhibition, June 19-24, 1994, Cincinnati, Ohio.

14 Billick, I.H., Wilson, A.L., Colome, S.D. and Tian, Y. "California Residential Indoor Air Quality Study: Methodology". Presented at the Air and Waste Management Association 87th Annual Meeting and Exhibition, June 19-24, 1994, Cincinnati, Ohio.

15 Colome, S.D., Fung, K., Behrens, D.W., Billick, I.H., Tian, Y. and Wilson, A.L. "Benzene and Toluene Concentrations Inside and Outside of Homes in California". Presented at the Air and Waste Management Association 87th Annual Meeting and Exhibition, June 19-24, 1994, Cincinnati, Ohio.

16 Colome, S.D., Garrison, C.A., Wilson, A.L. and Tian, Y. "Formaldehyde and Nitrogen Dioxide Concentrations Inside and Outside of Homes in California". Presented at the Air and Waste Management Association 87th Annual Meeting and Exhibition, June 19-24, 1994, Cincinnati, Ohio.

17 Spengler, J.D., Schwab, M., Ryan, P. B., Colome, S. D., Wilson, A. L., Billick, I., and Becker, E. "Personal Exposure to Nitrogen Dioxide in the Los Angeles Basin". Journal of the Air and Waste Management Association, 44:39-47, 1994.

18 Wilson, A.L. "Multiple Indoor Air Pollutant Characterization of California Residences. Presented at the 5th Annual West Coast Regional Conference on Current Issues in Air Toxics", November 9-10, 1994, Sacramento, California.

19 Wilson, A.L., Colome, S.D., and Tian, Y. California Residential Indoor Air Quality Study, Volume 2, Carbon Monoxide and Air Exchange Rate: A Univariate & Multivariate Analysis. Prepared for Gas Research Institute, Pacific Gas and Electric Company, San Diego Gas and Electric Company and Southern California Gas Company, July, 1994.

20 Wilson, A.L., Colome, S.D., Tian, Y., Becker, E.W., Behrens, D.W., Billick, I. H. and Garrison, C.A. "Carbon Monoxide Concentrations Inside and Outside of Homes in California". Presented at the Air and Waste Management Association 87th Annual Meeting and Exhibition, June 19-24, 1994, Cincinnati, Ohio.

21 Wilson, A.L., Colome, S.D., and Tian, Y. California Residential Indoor Air Quality Study, Volume 3, Ancillary and Exploratory Analyses. Prepared for Gas Research Institute, Pacific Gas and Electric Company, San Diego Gas and Electric Company and Southern California Gas Company, October, 1995.

Attachment E

Comments on Unintentional Non-Vehicular CO Deaths

Remarks

We believe that the CO death rates presented are too high and certainly do not reflect our experience with natural gas appliances.

The references cited (Girman *et al.*, 1998; Liu *et al.*, 1993a, 2000) were initially funded by PG&E and SoCalGas and represents the most specific and detailed evaluation of accidental CO poisoning deaths in California. Our main concern is that the data used in that study is quite old (1979-1988) and there have been many developments in the past 20 years to mitigate the impact of natural gas appliances on CO deaths. As an example, heating appliances with draft hoods are required to have a vent safety shutoff switch installed that will turn off the appliance in the event of a vent malfunction. In addition, test requirements for forced air furnace heat exchangers have been updated, and new venting methods have been developed for modern appliances.

Our evaluation of the initial CDHS effort resulted in the following observations that ARB should consider in their evaluation:

A. Number of Unintentional CO Deaths 1979-88

- 27 to 58 deaths per year (44 average)
- Average annual death rate equals 1.7 per million
- Non-vehicular related death rate 1.2 per million
- **Natural gas related death rate 0.4 per million**

B. Causes of Unintentional CO Deaths 1979-88

- Vehicles 31%
- Natural Gas Appliances 21%
- Charcoal Grills 13%
- Propane Appliances 7%
- Small engines 5%
- Fires 5%
- Camping Equipment 2%
- Unknown 4%

C. Natural Gas Appliances Involved in CO Deaths (21% total)

- Wall Furnace ` 9%
- Unvented Heater 3%
- Water Heater 2%
- Cooking Stove 2%
- Floor Furnace 2%
- Forced Air Furnace 2%

D. Alcohol and Drugs Involved

- Alcohol 31%
- Illegal Drugs 9%
- Prescription Drugs 7%

E. Relative Risk by Residence Type (for unintentional CO death)

- Single Family 1
- Multiple Family 2
- Mobile Homes 5
- Cabins, tents 30

F. Relative Risk by Heating Type (for unintentional CO death)

- Central FAU 1
- Floor or Wall Furnace 13
- Unvented Heater 45

G. Relative Risk by Fuel Usage (for unintentional CO death)

- Natural Gas 1
- Fuel Oil 2
- LPG 7

ARB recognized that the CO death rates have been falling and cited a CPSC study. A more recent CDC article may be more appropriate (Mott, 2002). It evaluated national mortality data from 1968 through 1998 and showed that the national average of all non-motor vehicle related unintentional CO death rates have been declining from 2.01 per million in 1968 to 0.34 per million in 1998. The CDHS data from 1979-1988 had an average non-vehicle death rate of 1.2, which seems to be in general agreement with the Mott data for that time period (1979=1.4; 1989= 0.8).

It seems reasonable to presume that the California non-vehicular related death rates have also been declining at approximately the same rate as the national figures and would be approximately 0.3 per million in 2004. **We would estimate 10 to 11 deaths per year statewide from all sources of unintentional non-vehicular related CO poisonings, not 20 to 26 as stated by ARB.**

It seems reasonable to presume that the California non-vehicular related death rates have also been declining at approximately the same rate as the national figures and would be approximately 0.3 per million in 2004. Using that ratio, **we would estimate 10 to 11 deaths per year statewide from all sources of unintentional non-vehicular related CO poisonings, not 20 to 26 as stated by ARB.**

As shown by the original CDHS study, CO poisoning from natural gas appliances resulting in death in California is a rare occurrence. Our records indicate that over the

last 5 years the death rate has averaged less than two per year in our combined service territories that were possibly related to a gas appliance. **It seems unreasonable to assume that the statewide the death rates from malfunctioning natural gas appliances could have exceeded more than 3 or 4 per year during the past five years.**

The decline in unintentional non-vehicular CO deaths observed nationwide has been occurring at least since 1968. The draft report asserts that some of that decline may be due to the use of low cost CO alarms. That hypothesis was rejected by Mott. CO alarm usage did not become widespread until the early 1990"s and less than one third of the homes have CO alarms.

The safe use of appliances by our customers is an extremely important issue for SoCalGas and SDG&E. We have outreach programs, educational materials and "bill stuffers" to help our customers use their appliances safely. We offer free appliance inspections that also include CO testing when appropriate. If our service staff encounters an unvented natural gas heater, it is turned off and the customer is advised that they are not allowed in California. Any gas appliance determined to be unsafe is turned off and the customer is advised to have it fixed or replaced if our service person cannot remedy the situation. We have a very active low income energy efficiency program that involves inspecting thousands of appliances in low income homes every year.

Recommendations

1. Revise the death rate assumptions and the resulting costs presented on pages 80, 81 and 133.
2. Separate natural gas combustion from other combustion sources in the tables to reflect the lower CO death rates from natural gas appliances.
3. Delete assertions that CO alarms have reduced unintentional non-vehicular CO death rates.

Reference on CO Deaths

Mott, J. A., et al, National Vehicle Emission Policies and Practices and Declining Carbon Monoxide-Related Mortality, JAMA, Vol 288, No. 8, Aug 28, 2002.

Attachment F

Comments on Cooking Emissions

Remarks

There have been three major efforts reported in the literature that have specifically measured and quantified emissions from residential cooking activities. The first group to conduct testing was the Center for Indoor Air Research (CIAR) in 1995-1996.[1,2] They contracted with Wolfgang Rogge of the Florida International University to conduct emissions tests in an exposure chamber. The second effort was the California Air Resources Board (CARB) in 1998-2000.[3] They contracted with ARCADIS Geraghty & Miller, Inc. to conduct testing in one test house. The Gas Research Institute (GRI) contracted with Battelle to conduct tests in an exposure chamber in 1999 followed by testing in one test house in 2000.[4]

Each group developed their testing protocols to simulate "typical" residential cooking activities. However, the amounts of foods cooked was sometimes much larger than in a typical home so that it would be easier to measure the pollutant concentrations. Each group used one gas range and one electric range for all of their tests. CARB also used a microwave oven for a few tests. Foods, amounts, duration times, techniques and utensils were chosen by each group. These choices resulted in only a few tests that were similar and most cooking tests could not be directly compared between groups.

CARB and GRI produced expansive reports of their efforts with detailed information on their methodologies and results. The CIAR effort has only been reported in two short papers that presented only summaries of selected tests comparing gas and electric cooking results.

Each of the three research groups independently chose their test protocols, cooking activities, parameters monitored and measurement methods. Each group presented their findings in different formats, emphasizing the parameters of most interest to that group. Common to all three groups were measurements of CO, NO_2, $PM_{2.5}$ and PM_{10}. CARB and GRI also measured formaldehyde and PAHs. The test results of those common parameters are presented in these comments for each cooking activity. CIAR did not measure CO or NO_2 during emission tests of the electric range. Automatic oven cleaning was evaluated by CARB and GRI and found to be very significant for both gas and electric ranges. However, it is not included in this emission summary due to the high variability of the data and the difficulty of comparing the GRI and CARB test protocols.

A main objective in this review of the cooking tests is to compare the emissions between cooking with a gas range versus cooking with an electric range. There is no one emission factor that will give a complete view of the emissions from a cooking activity. For example, mass of pollutant per minute of cooking may be of more interest in some analyses than in the total mass of pollutant released during the cooking activity. We have chosen to present the results as a function of the amount of food cooked for each cooking

activity. All results are presented as the emissions (micrograms) of a pollutant per mass (grams) of food cooked. The mass of food cooked includes the oil used in the cooking process.

We have grouped the cooking activities by appliance type, cooking element and food. This allows the clearest comparison between electric and gas cooking for the three research efforts. The cooking element groups are: oven baking; oven broiling; top deep frying; top pan frying; and, microwave.

Tables 1 through 6 lists the emissions in terms of pollutant mass per unit mass of food cooked. For CARB and GRI, each listed result is for one test. The CIAR results presented are an average of several tests since only summaries were reported in the literature.

It is clear from a review of these three studies that emissions of all measured pollutants (CO, NO_2, formaldehyde, PAH and PM) are emitted while cooking foods on gas or electric ranges. **Cooking emission testing studies have shown that the foods cooked and the cooking techniques used are more important to indoor air quality than the type of appliance used to cook the food.** For example, burning popcorn in a microwave oven can cause a higher IAQ health risk than cooking popcorn on a properly operating gas range without burning the food. Efforts to reduce the impact of cooking activities to improve indoor air quality must consider what is being cooked, how it is cooked, and both gas and electric appliances.

Recommendations

1. Revise statements made about cooking emissions to make it clear that all cooking appliances (gas, electric, microwave ovens, toasters, etc) are included.
2. Include electric cooking appliances in discussions of CO, NO_2, formaldehyde and PAH emissions and impacts.
3. Include all cooking appliance types when discussing the need to control emissions, ventilate the home, reduce health effects or reduce impacts.

References for Cooking Comments

1 Rogge, Wolfgang F., Cui, W., Zhang, Z., Yan, Y., and Sit, S., “Gaseous and Particle Emission Rates for Residential Food Cooking”, In: Proceeding of the Engineering Solutions to Indoor Air Quality Problems, Air and Waste Management Association, July, 1997

2 Rogge, Wolfgang F., Wenxuan Cui, Zhihua Zhang, Yujun Yan, and Sampson Sit, “Characterizations of Gaseous and Particulate Emissions from Natural Gas Cooking Flames on a Molecular Level,” In: Proceeding of the Engineering Solutions to Indoor Air Quality Problems, Air and Waste Management Association, July, 1997

3. Fortmann, Roy, Kariher, P., and Clayton, R. Indoor Air Quality: Residential Cooking Exposures Final Report, State of California Air Resources Board, Research Division, Contract Number 97-330, Sacramento, CA, November, 2001

4. Kelly, Thomas J. Measurements of Particulate and Vapor Emissions from Cooking Activities Final Report, Gas Research Institute, Des Plaines, Ill, GRI-01/0098, July, 2001

Table 1
$PM_{2.5}$ Cooking Emissions per Mass of Food Cooked (ug/g)

Cooking Activity	Cooking Emissions (ug/g)	
	Electric	Gas
Oven Baking		
Beef and Pork, CIAR	70	130
Bread, GRI	10	16
Bread, GRI	12	19
Bread, GRI	13	39
Lasagna, CARB	44	453
Pizza, CIAR	50	50
Pork Roast, GRI	2	2
Pork Roast, GRI	4	6
Pork Roast, GRI	7	21
Turkey, GRI	3	6
Oven Broiling		
Beef Steak, CIAR	70	110
Beef Steak, GRI	68	156
Beef Steak, GRI	97	217
Beef Steak, GRI	227	330
Fish, CARB	164	224
Pork Chops, GRI	419	204
Top Deep Fry		
French Fries, CARB	22	15
French Fries, CIAR	110	90
French Fries, GRI	9	4
Top Pan Fry		
Bacon, CARB	83	167
Bacon, CARB	NA	192
Chicken & vegs, CARB	58	70
Chicken & vegs, CARB	NA	257
Fish, CIAR	670	980
Fish, GRI	35	13
Fish, GRI	61	34
Ground Beef, GRI	15	9
Ground Beef, GRI	28	11
Ground Beef, GRI	161	17
Meats, CIAR	310	330
Mixed Vegetables, CIAR	70	90
Tortillas, CARB	232	103

Cooking Activity	Cooking Emissions (ug/g)
	Gas
Oven Baking	
Lasagna, CARB	154
Pork Roast, CARB	2
Pork Roast, CARB	14
Pork Roast, CARB	83
Oven Broiling	
Fish, CARB	141
Top Deep Fry	
French Fries, CARB	13
Top Pan Fry	
Chicken & vegs, CARB	33
Chicken & vegs, CARB	72
Ground Beef, CARB	10
Ground Beef, CARB	17
Ground Beef, CARB	29
Ground Beef, CARB	64
Ground Beef, CARB	99

Table 2
PM_{10} Cooking Emissions per Mass of Food Cooked (ug/g)

Cooking Activity	Cooking Emissions (ug/g)	
	Electric	Gas
Oven Baking		
Beef and Pork, CIAR	170	510
Bread, GRI	10	19
Bread, GRI	12	24
Bread, GRI	15	35
Lasagna, CARB	234	127
Pizza, CIAR	60	60
Pork Roast, GRI	1	2
Pork Roast, GRI	2	7
Pork Roast, GRI	11	25
Turkey, GRI	4	5
Oven Broiling		
Beef Steak, CIAR	110	200
Beef Steak, GRI	74	167
Beef Steak, GRI	120	265
Beef Steak, GRI	268	413
Fish, CARB	413	213
Pork Chops, GRI	396	238
Top Deep Fry		
French Fries, CARB	18	41
French Fries, CIAR	140	110
French Fries, GRI	10	6
Top Pan Fry		
Bacon, CARB	172	132
Bacon, CARB	NA	452
Chicken & vegs, CARB	450	110
Chicken & vegs, CARB	NA	425
Fish, CIAR	1270	1500
Fish, GRI	53	18
Fish, GRI	97	36
Ground Beef, GRI	19	14
Ground Beef, GRI	35	22
Ground Beef, GRI	210	23
Meats, CIAR	990	1020
Mixed Vegetables, CIAR	200	370
Tortillas, CARB	351	65

Cooking Activity	Cooking Emissions (ug/g)
	Gas
Oven Baking	
Lasagna, CARB	68
Pork Roast, CARB	21
Pork Roast, CARB	32
Pork Roast, CARB	48
Oven Broiling	
Fish, CARB	641
Top Deep Fry	
French Fries, CARB	23
Top Pan Fry	
Chicken & vegs, CARB	206
Chicken & vegs, CARB	243
Ground Beef, CARB	35
Ground Beef, CARB	45
Ground Beef, CARB	52
Ground Beef, CARB	67
Ground Beef, CARB	144

Table 3
Carbon Monoxide Cooking Emissions per Mass of Food Cooked (ug/g)

Cooking Activity	Cooking Emissions (ug/g)	
	Electric	Gas
Oven Baking		
Bread, GRI	14	205
Bread, GRI	14	273
Bread, GRI	14	287
Lasagna, CARB	75	966
Pork Roast, GRI	7	192
Oven Broiling		
Beef Steak, GRI	43	268
Beef Steak, GRI	59	363
Fish, CARB	1216	3881
Fish, CARB	2155	6735
Top Deep Fry		
French Fries, CARB	309	1104
Top Pan Fry		
Bacon, CARB	26	119
Bacon, CARB	61	378
Chicken & vegs, CARB	40	464
Ground Beef, GRI	12	30
Ground Beef, GRI	12	53
Ground Beef, GRI	13	76
Tortillas, CARB	149	134

Cooking Activity	Cooking Emissions (ug/g)
	Gas
Oven Baking	
Beef and Pork, CIAR	1730
Lasagna, CARB	714
Pizza, CIAR	1320
Pork Roast, CARB	201
Pork Roast, CARB	333
Oven Broiling	
Beef Steak, CIAR	2230
Fish, CARB	4100
Fish, CARB	5428
Top Deep Fry	
French Fries, CARB	384
French Fries, CIAR	140
Top Pan Fry	
Bacon, CARB	723
Bacon, CARB	1034
Chicken & vegs, CARB	444
Chicken & vegs, CARB	487
Chicken & vegs, CARB	588
Chicken & vegs, CARB	669
Chicken & vegs, CARB	843
Chicken & vegs, CARB	993
Fish, CIAR	270
Ground Beef, CARB	53
Ground Beef, CARB	70
Ground Beef, CARB	93
Ground Beef, CARB	138
Ground Beef, CARB	156
Ground Beef, CARB	164
Meats, CIAR	450
Mixed Vegetables, CIAR	590

Cooking Activity	Cooking Emissions (ug/g)
Microwave	
Bacon, CARB	0
Bacon, CARB	221
Lasagna, CARB	25
Popcorn, CARB	0
Popcorn, CARB	495

Table 4
Nitrogen Dioxide Cooking Emissions per Mass of Food Cooked (ug/g)

Cooking Activity	Cooking Emissions (ug/g)	
	Electric	Gas
Oven Baking		
Bread, GRI	BDL	28
Bread, GRI	BDL	36
Bread, GRI	BDL	37
Bread, GRI	2	52
Lasagna, CARB	21	63
Pork Roast, GRI	BDL	21
Pork Roast, GRI	2	57
Turkey, GRI	1	27
Oven Broiling		
Beef Steak, GRI	BDL	30
Beef Steak, GRI	BDL	34
Beef Steak, GRI	4	39
Fish, CARB	22	98
Fish, CARB	29	109
Pork Chops, GRI	2	86
Top Deep Fry		
French Fries, CARB	2	10
French Fries, GRI	BDL	16
Top Pan Fry		
Bacon, CARB	18	27
Bacon, CARB	25	47
Chicken & vegs, CARB	5	21
Fish, GRI	BDL	35
Ground Beef, GRI	BDL	15
Ground Beef, GRI	BDL	15
Ground Beef, GRI	BDL	16
Ground Beef, GRI	BDL	17
Tortillas, CARB	8	11

Cooking Activity	Cooking Emissions (ug/g)
Microwave	
Bacon	9
Bacon	20
Lasagna	7
Popcorn	21
Popcorn	35

Cooking Activity	Cooking Emissions (ug/g)
	Gas
Oven Baking	
Beef and Pork, CIAR	110
Bread, GRI	22
Pizza, CIAR	90
Pork Roast, CARB	8
Pork Roast, GRI	39
Oven Broiling	
Beef Steak, CIAR	11
Beef Steak, GRI	120
Fish, CARB	166
Fish, CARB	153
Top Deep Fry	
French Fries, CARB	15
French Fries, CIAR	100
French Fries, GRI	4
Top Pan Fry	
Bacon, CARB	36
Bacon, CARB	45
Chicken & vegs, CARB	17
Chicken & vegs, CARB	18
Chicken & vegs, CARB	20
Chicken & vegs, CARB	27
Chicken & vegs, CARB	28
Chicken & vegs, CARB	29
Fish, CIAR	110
Fish, GRI	13
Fish, GRI	14
Fish, GRI	28
Ground Beef, CARB	4
Ground Beef, CARB	10
Ground Beef, CARB	10
Ground Beef, CARB	11
Ground Beef, CARB	11
Ground Beef, CARB	12
Ground Beef, GRI	7
Ground Beef, GRI	8
Ground Beef, GRI	41
Meats, CIAR	90
Mixed Vegetables, CIAR	60

BDL= Below Detectable Limit

Table 5
Formaldehyde Cooking Emissions per Mass of Food Cooked (ug/g)

Cooking Activity	Cooking Emissions (ug/g)	
	Electric	Gas
Oven Baking		
Bread, GRI	0	3
Bread, GRI	0	4
Bread, GRI	0	4
Bread, GRI	18	10
Bread, GRI	4	7
Pork Roast, GRI	3	8
Pork Roast, GRI	1	6
Turkey, GRI	1	4
Oven Broiling		
Beef Steak, GRI	2	13
Beef Steak, GRI	3	14
Beef Steak, GRI	4	24
Beef Steak, GRI	59	28
Fish, CARB	26	34
Pork Chops, GRI	43	78
Top Deep Fry		
French Fries, GRI	2	0
Top Pan Fry		
Fish, GRI	4	1
Fish, GRI	4	5
Ground Beef, GRI	0	0
Ground Beef, GRI	0	1
Ground Beef, GRI	0	1
Ground Beef, GRI	0	1
Ground Beef, GRI	2	7

Cooking Activity	Cooking Emissions (ug/g)
	Gas
Oven Baking	
Pork Roast, CARB	2
Pork Roast, CARB	11
Pork Roast, GRI	16

Table 6
Polynuclear Aromatic Hydrocarbons Cooking Emissions per Mass of Food Cooked (ug/g)

Cooking Activity	Cooking Emissions (ug/g)	
	Electric	Gas
Oven Baking		
Turkey, GRI	0.001	0.002
Pork Roast, GRI	0.003	0.004
Pork Roast, GRI	0.003	0.009
Bread, GRI	0.001	0.003
Bread, GRI	0.003	0.003
Bread, GRI	0.003	0.008
Bread, GRI	0.003	0.013
Bread, GRI	0.004	0.015
Oven Broiling		
Pork Chops, GRI	0.031	0.001
Beef Steak, GRI	0.012	0.012
Beef Steak, GRI	0.029	0.015
Beef Steak, GRI	0.029	0.016
Beef Steak, GRI	0.036	0.081
Beef Steak, GRI	0.037	0.113
Top Deep Fry		
French Fries, GRI	0.003	0.006
Top Pan Fry		
Ground Beef, GRI	0.001	0.004
Ground Beef, GRI	0.005	0.005
Ground Beef, GRI	0.006	0.006
Ground Beef, GRI	0.014	0.007
Ground Beef, GRI	0.020	0.013
Fish, GRI	0.019	0.007
Fish, GRI	0.021	0.008

Attachment G

Comments on Ranking Source Categories

Remarks

Our main comment regarding the ranking is that the report does not follow the mandate given in AB1173. The report deviates from the mandate and in doing so has attempted to answer a question that is too complex to be addressed this early in the process. The resulting ranking presented in the report is apparently the opinion of the authors and not based upon a scientific methodology.

AB1173 mandated the following pertaining to ranking (bold added)

(b) The report described in subdivision (a) shall include all of the following:

> *(1) A list of indoor air pollutants that are described in the summaries provided pursuant to paragraphs (1) and (4) of subdivision (a).*
>
> *(2) A list of indoor **air pollutants**, as defined in Section 39013, **ranked in groups designated as high, medium, and lower priorities**, that the state board has determined, based upon empirical data or other scientific information, are likely to have the most significant adverse impacts on human health through exposures in schools, nonindustrial workplaces, homes, and other indoor locations, **and the probable source categories for these pollutants**.*
>
> *(3) An analysis of the indoor emissions, indoor exposures, and potential health effects from the indoor source categories described in paragraph (1), and options for mitigating those health effects in schools, non-industrial workplaces, homes, and other indoor locations, including, but not limited to, a discussion of the feasibility and public health effects of implementing each option.*
>
> *(4) A description of options for schools and school districts to improve indoor air quality in public schools. The state board shall develop these options in consultation with representatives from school district facility departments, school district maintenance departments, and statewide educational organizations.*

Page 123 of the draft report states (bold added): "The primary criteria used in **prioritizing the source categories** included the extent of the population's **exposure** to the sources and their emissions, and the relative **reduction in health impacts** that could be achieved with action."

Clearly the ranking does not address paragraph (b) of AB1173. Furthermore, the report doesn't present the quantification of the exposures nor does it calculate specific health impact reductions for the listed source categories. Without stating the empirical data or

other scientific information used in the criteria the readers are left to assume that it's just the opinion of the authors.

As stated in other sections of our comments, we suggest that natural gas appliances and other combustion sources not be included in one category. It is misleading and is too general to be useful in prioritizing emissions, impacts or control strategies.

Even for natural gas appliances one category is also not very useful. The following categorization, subject to further refinement, is suggested for IAQ issues related to gas appliances:

Cook tops (with standing pilots)
- With fume hood vented outside
- With fume hood vented inside
- Without fume hood

Cook tops (without standing pilots)
- With fume hood vented outside
- With fume hood vented inside
- Without fume hood

Oven/Broilers (with standing pilots)
- Vented outside
- Not vented
- With fume hood vented outside

Oven/Broilers (without standing pilots)
- Vented outside
- Not vented
- With fume hood vented outside

Forced Air Furnaces
- Atmospheric
    - Attic
    - Closet
    - Garage
    - Conditioned space
- Direct vent
- Induced draft
    - Attic
    - Closet
    - Garage
    - Conditioned space
- Power vent
    - Attic

    - Closet
    - Garage
    - Conditioned space

Wall Furnaces

- Built in vent
- Direct vent

Freestanding vented room heaters

Floor Furnaces

Gravity Furnaces

Storage Water Heaters

- Atmospheric
    - Attic
    - Closet
    - Garage
    - Conditioned space
- Direct vent
    - Attic
    - Closet
    - Garage
    - Conditioned space
- Power vent
    - Attic
    - Closet
    - Garage
    - Conditioned space

Instantaneous Water Heaters

- Atmospheric
    - Attic
    - Closet
    - Garage
    - Conditioned space
- Direct vent
    - Attic
    - Closet
    - Garage
    - Conditioned space
- Induced draft
    - Attic
    - Closet
    - Garage
    - Conditioned space

Clothes Dryers

- In conditioned space
- Not in conditioned space

Fireplaces

- Gas log
- Gas log lighter

Other gas appliances

- Unvented
    - In conditioned space
    - Not in conditioned space

As the above categories demonstrate, discussion of the emissions and resultant IAQ impacts from natural gas appliances is complex.

Recommendations

1. List pollutants (not source categories) ranked by high, medium and lower priorities
2. Fully describe the methodology used in the ranking process or algorithm
3. List the specific empirical data or other scientific information used